Architecture & Design Characteristics/Controls

NIST Big Data Working Group, Definitions and Taxonomy Subgroup

UCSD, Super Computing Facility
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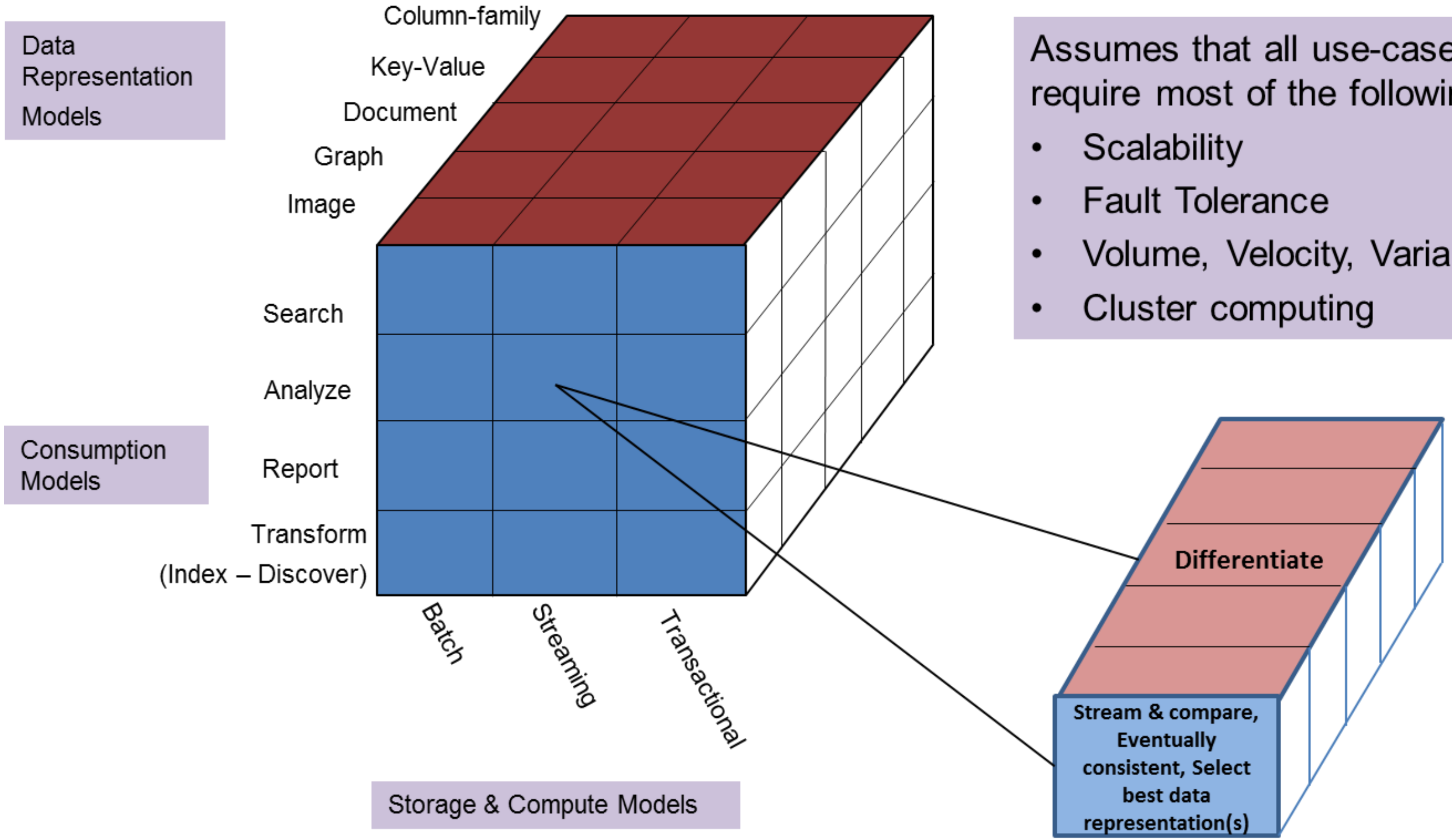
John Rogers, Master Technical Consultant, HP
Nancy Grady, PhD, Technical Fellow, SAIC

Big Data Architecture Characteristics Cube



Assumes that all use-cases require most of the following:

- Scalability
- Fault Tolerance
- Volume, Velocity, Variability
- Cluster computing

Big Data Projects Risk Avoidance?

COBIT® 5
AN ISACA® FRAMEWORK

ITIL®

ISO International Organization for Standardization

KODB
KOREA DATABASE AGENCY

JSA Japanese Standards Association

GB
STANDARDS PRESS OF CHINA

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

CMMI®

BSi British Standards

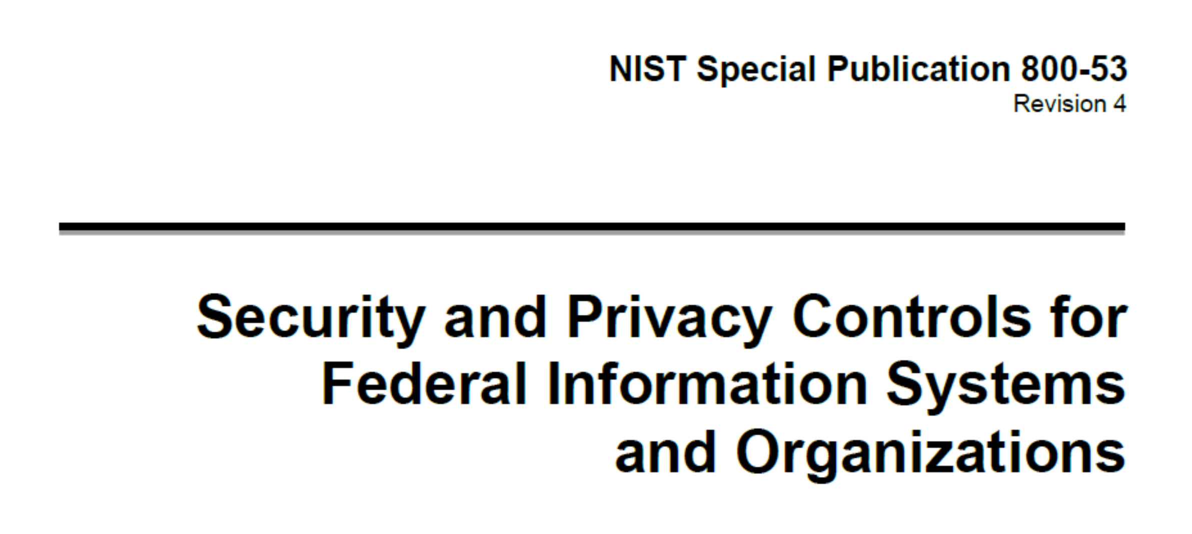
DIN

iDA INFOCOMM DEVELOPMENT AUTHORITY OF SINGAPORE

ETSI

Business Purpose, Concerns, Risks, Guidance, and Execution

by way of Example



NIST Special Publication 800-53
Revision 4

Security and Privacy Controls for Federal Information Systems and Organizations

Our big data assignment, today

Provide detailed guidance to the solutions architects and designers to:

- Build me a system that streams web page hits to a classification model and spits out alerts if a customer meets or exceeds a high-interest thresh-hold.
- Provide continuous monitoring and validation of algorithm performance.
- Provenance is unimportant.
- Data consumers do not need special analysis, fusion, or visualization tools.
- This is primarily an alerting system.
- Scale is 2TB's per week. Retain history for 5 years. Plan for future expansion.
- Provide assurances that the system will work as planned

How do we approach this?

By analogy

Follow the pattern of NIST SP 800-53, Version 4, 4/30/2013

“Security and Privacy Controls for Federal Information Systems and Organizations”

http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-53r4.pdf

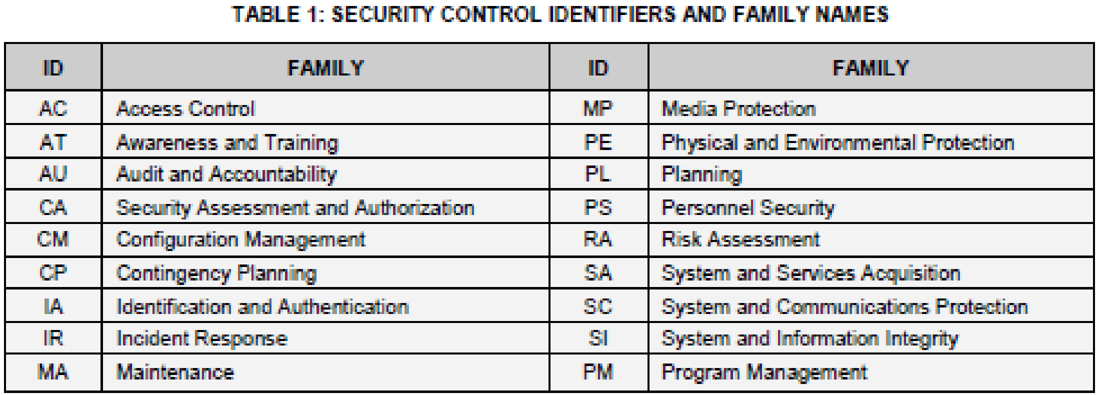
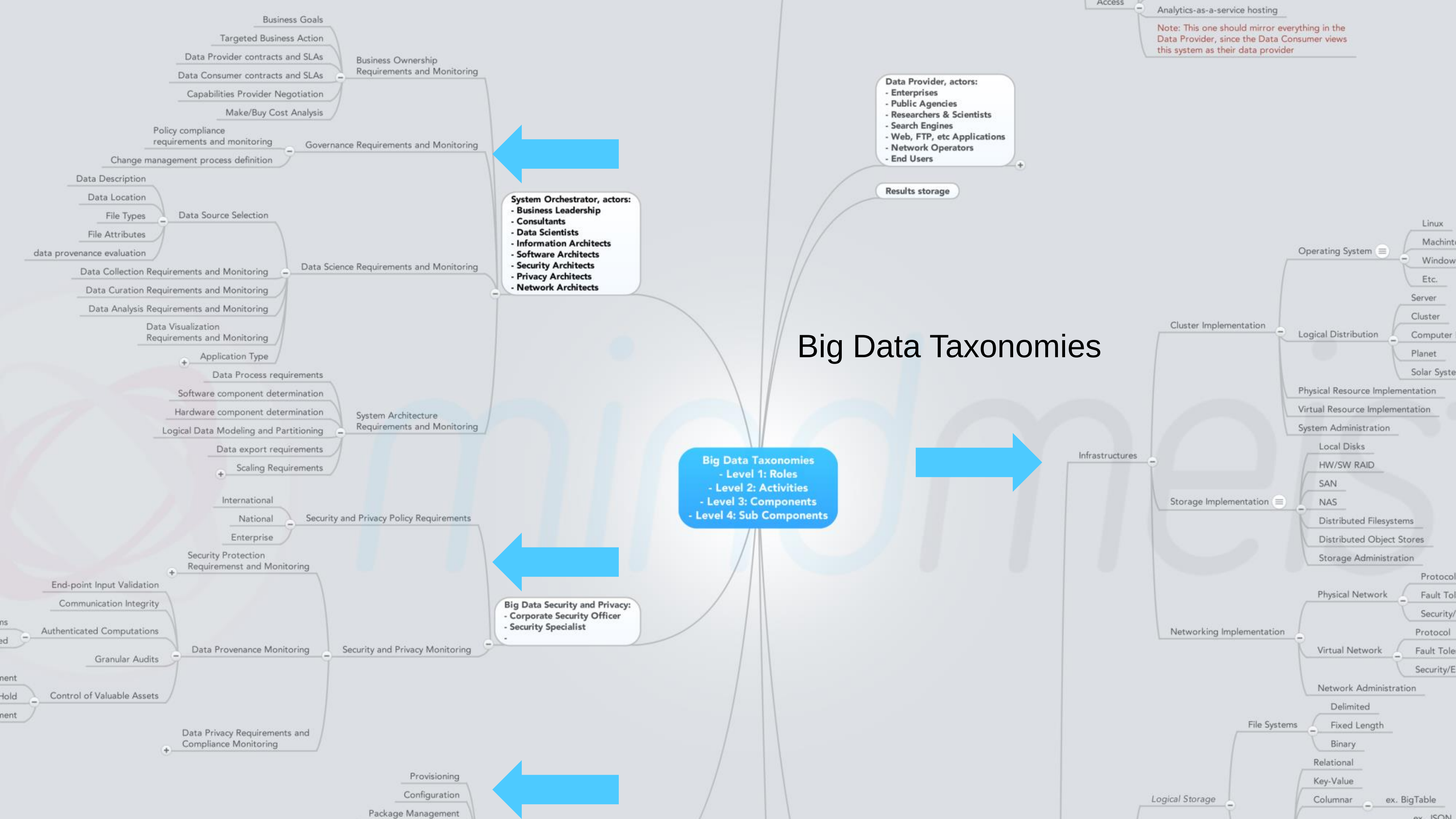


TABLE 1: SECURITY CONTROL IDENTIFIERS AND FAMILY NAMES

ID	FAMILY	ID	FAMILY
AC	Access Control	MP	Media Protection
AT	Awareness and Training	PE	Physical and Environmental Protection
AU	Audit and Accountability	PL	Planning
CA	Security Assessment and Authorization	PS	Personnel Security
CM	Configuration Management	RA	Risk Assessment
CP	Contingency Planning	SA	System and Services Acquisition
IA	Identification and Authentication	SC	System and Communications Protection
IR	Incident Response	SI	System and Information Integrity
MA	Maintenance	PM	Program Management

Big Data Taxonomies



Big Data Taxonomies
- Level 1: Roles
- Level 2: Activities
- Level 3: Components
- Level 4: Sub Components

System Orchestrator, actors:
- Business Leadership
- Consultants
- Data Scientists
- Information Architects
- Software Architects
- Security Architects
- Privacy Architects
- Network Architects

Business Ownership Requirements and Monitoring
- Business Goals
- Targeted Business Action
- Data Provider contracts and SLAs
- Data Consumer contracts and SLAs
- Capabilities Provider Negotiation
- Make/Buy Cost Analysis

Governance Requirements and Monitoring
- Policy compliance requirements and monitoring
- Change management process definition

Data Science Requirements and Monitoring
- Data Source Selection
  - Data Description
  - Data Location
  - File Types
  - File Attributes
  - data provenance evaluation
- Data Collection Requirements and Monitoring
- Data Curation Requirements and Monitoring
- Data Analysis Requirements and Monitoring
- Data Visualization Requirements and Monitoring
- Application Type

System Architecture Requirements and Monitoring
- Data Process requirements
- Software component determination
- Hardware component determination
- Logical Data Modeling and Partitioning
- Data export requirements
- Scaling Requirements

Big Data Security and Privacy:
- Corporate Security Officer
- Security Specialist
-

Security and Privacy Policy Requirements
- International
- National
- Enterprise

Security and Privacy Monitoring
- Security Protection Requirement and Monitoring
- Data Provenance Monitoring
  - End-point Input Validation
  - Communication Integrity
  - Authenticated Computations
    - ns
    - ed
  - Granular Audits
  - Control of Valuable Assets
    - nent
    - Hold
    - nent
- Data Privacy Requirements and Compliance Monitoring

Provisioning
Configuration
Package Management

Access
- Analytics-as-a-service hosting
- Note: This one should mirror everything in the Data Provider, since the Data Consumer views this system as their data provider

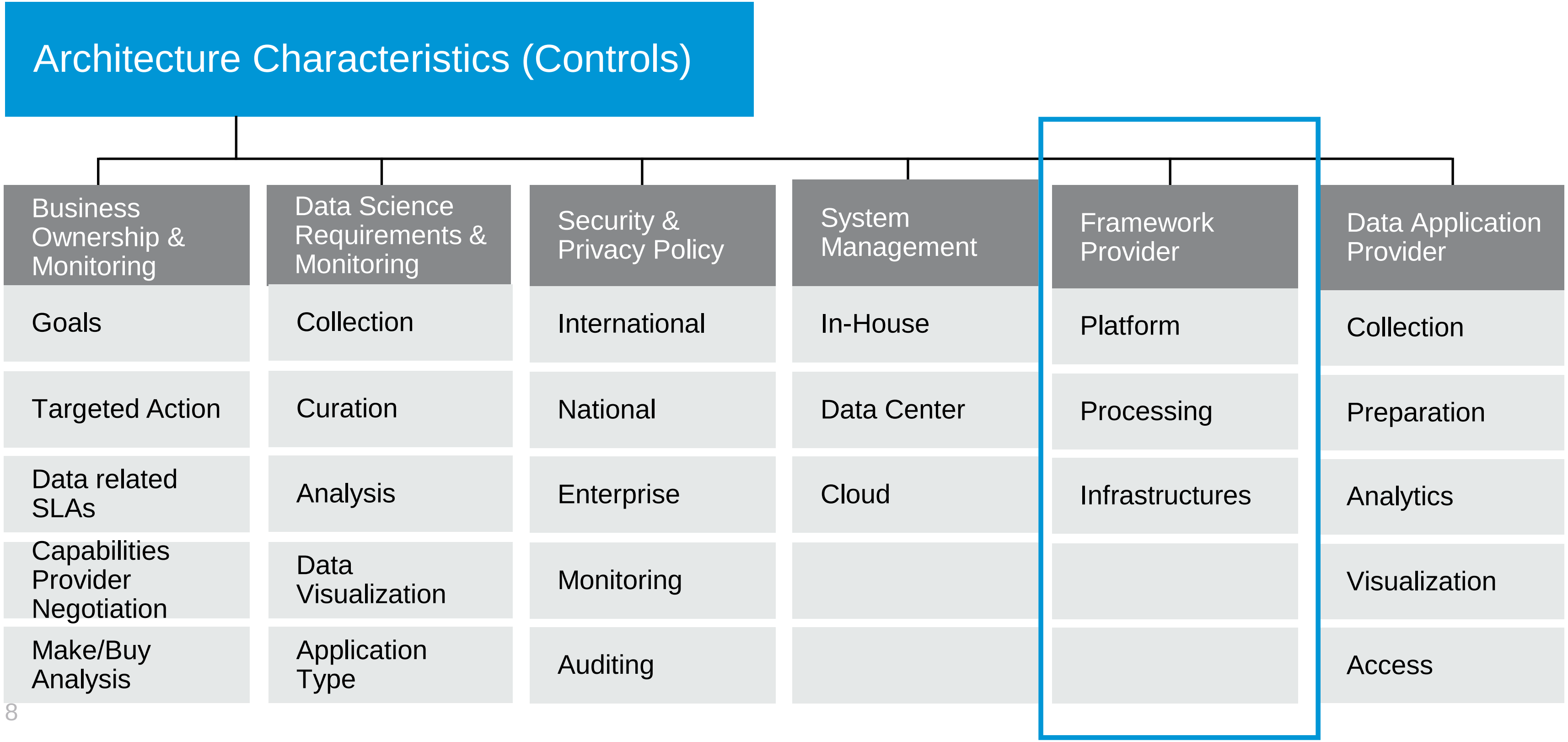
Data Provider, actors:
- Enterprises
- Public Agencies
- Researchers & Scientists
- Search Engines
- Web, FTP, etc Applications
- Network Operators
- End Users

Results storage

Infrastructures
- Cluster Implementation
  - Operating System
    - Linux
    - Machint
    - Window
    - Etc.
  - Logical Distribution
    - Server
    - Cluster
    - Computer
    - Planet
    - Solar Syste
  - Physical Resource Implementation
  - Virtual Resource Implementation
  - System Administration
- Storage Implementation
  - Local Disks
  - HW/SW RAID
  - SAN
  - NAS
  - Distributed Filesystems
  - Distributed Object Stores
  - Storage Administration
- Networking Implementation
  - Physical Network
    - Protocol
    - Fault Tol
    - Security/
  - Virtual Network
    - Protocol
    - Fault Tole
    - Security/E
  - Network Administration

Logical Storage
- File Systems
  - Delimited
  - Fixed Length
  - Binary
- Relational
- Key-Value
- Columnar
  - ex. BigTable
  - ex. JSON

Big Data Taxonomies



Architecture Characteristics (Controls)

Business Ownership & Monitoring	Data Science Requirements & Monitoring	Security & Privacy Policy	System Management	Framework Provider	Data Application Provider
Goals	Collection	International	In-House	Platform	Collection
Targeted Action	Curation	National	Data Center	Processing	Preparation
Data related SLAs	Analysis	Enterprise	Cloud	Infrastructures	Analytics
Capabilities Provider Negotiation	Data Visualization	Monitoring			Visualization
Make/Buy Analysis	Application Type	Auditing			Access

Characteristic (Control) Identifiers and Family names

ID	Family	ID	Family
BO	Business Ownership Monitoring	DC	Data Consumer
DS	Data Science Requirements Monitoring	DP	Data Provider
SP	Security & Privacy Policy	**FP**	**Framework Provider**
SM	System Management	DA	Data Applications Provider

Family Names are consistent with Level 1 (Roles) in the Big Data Taxonomy

Example: Drill-down into Framework Provider activities

Framework Provider Family (FP)			
ID	**Activity**		
IN	**Infrastructure**		
PL	Platform		
PF	Processing Framework		

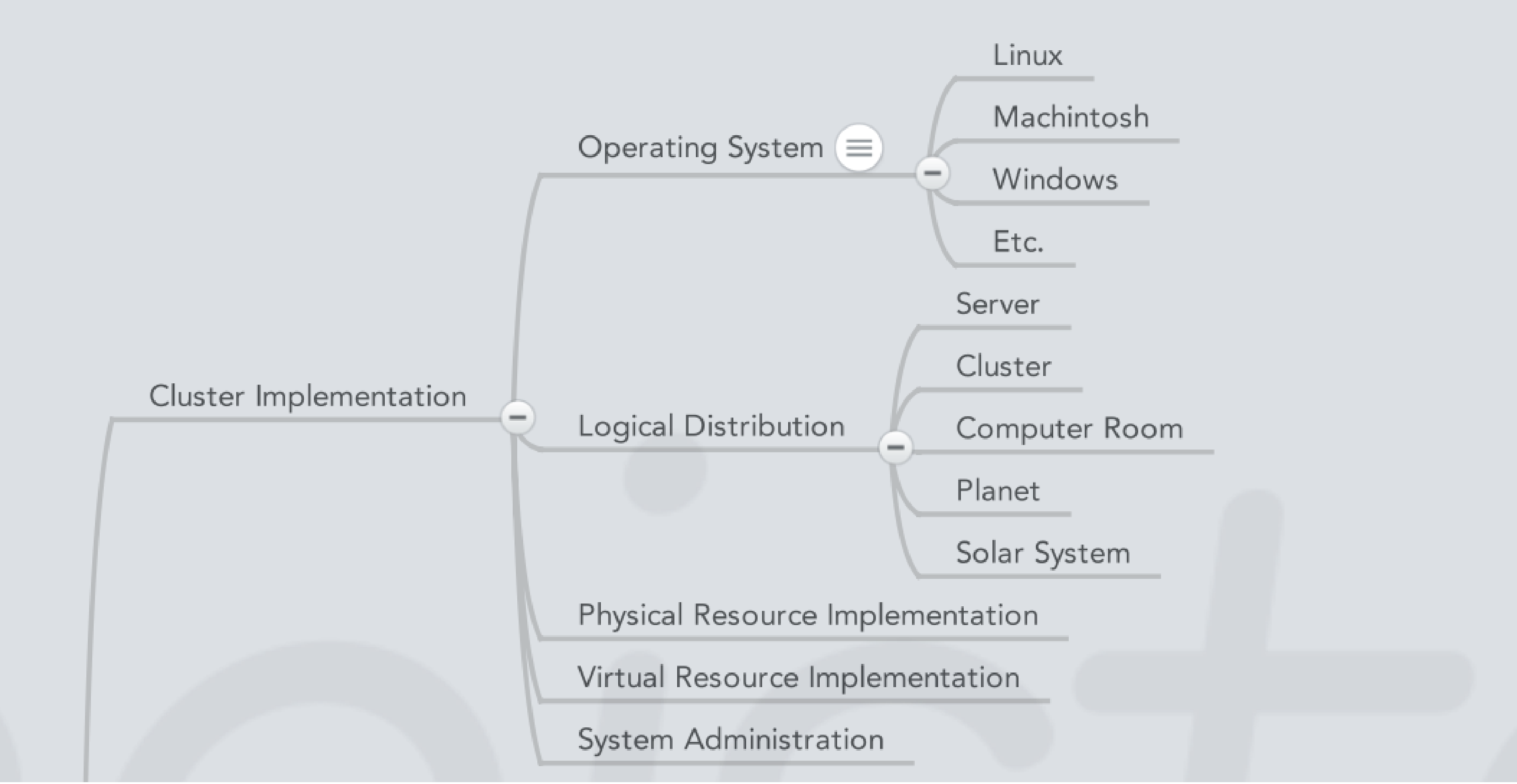
Activity categories are consistent with Level 2 (Activities) in the Big Data Taxonomy

Drill down to Framework Provider, Infrastructure Activity components

Framework Provider Family (FP)			
Infrastructure Activity (I)			
ID	**Component**		
CL	**Cluster**		
ST	**Storage**		
NW	Network		

Implementation categories are consistent with Level 3 (Components) in the Big Data Taxonomy

Infrastructure Cluster Implementation



Cluster Implementation

Operating System

Linux

Machintosh

Windows

Etc.

Logical Distribution

Server

Cluster

Computer Room

Planet

Solar System

Physical Resource Implementation

Virtual Resource Implementation

System Administration

Drill down to Framework Provider, Infrastructure Activity, Cluster and Storage Sub-components

Framework Provider Family (FP)			
Infrastructure Activity (I)			
Cluster (C)		Storage (S)	
ID	**Sub-Component**	ID	Sub-Component
DR	Logical Distribution	**DF**	**Distributed File System**
PR	**Physical Resource**	DO	Distributed Object Store
VR	Virtual Resource	RD	RAID
OS	Operating System	**DD**	Disk type **(HDD, SDD,** Array, Network)
SA	System Administration	SN	Storage Administration

Sub-categories are consistent with Level 4 (Sub-Components)

Drill down to Framework Provider, Infrastructure Activity, Cluster Sub-component, Physical Resource

Framework Provider Family (FP)			
Infrastructure Activity (I)			
Cluster Component (C)			
Physical Resource Sub-component (PR)			
ID	**Sub-Component**	Commodity Server Performance	
1	**Commodity Server**	1	Base
2	Server-SAN	**2**	**Mid**
3	Custom Server	3	High

FP-I-C-PR-12 (Mid-range server)

Additional Characteristics (controls)

Guidance for today’s assignment

FP-I-C-PR-13 (Mid Range Server)

BO-MB (High)

SP-PM (low)

DS-CM (Med)

DS-AM (Med)

DC-VA (High)

DC-SR (Low)

DP-WC (High)

DA-AP-ML-CL (High)

DA-AP-ML-DF (Med)

DA-AP-ML-SA (Low)

- Build me a system that *streams* web page hits in a *classification* model and spits out *alerts* if a customer meets or exceeds a high-interest thresh-hold.
- Provide continuous monitoring and validation of algorithm performance.
- Provenance is not important.
- Data consumers do not need special analysis, fusion, or visualization tools.
- This is primarily an alerting system.
- Scale is TB’s per week.
- Keep capital cost reasonable.
- Infrastructure selection based on testing

Again, by way of Example

Ex: Evaluate Workloads

TeraSort

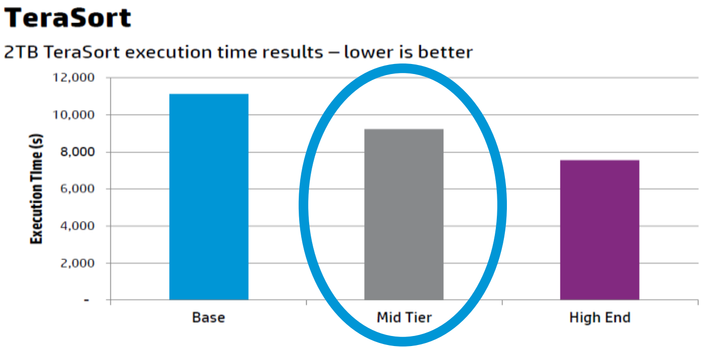
- Base workload: Find, Shuffle, Sort in Order
- Good Overall utilization (CPU, Memory, Disk, Network IO)

Intel Hi-Bench Workloads

- Web-Search: K-V Indexing
- Machine Learning: K-Means Clustering

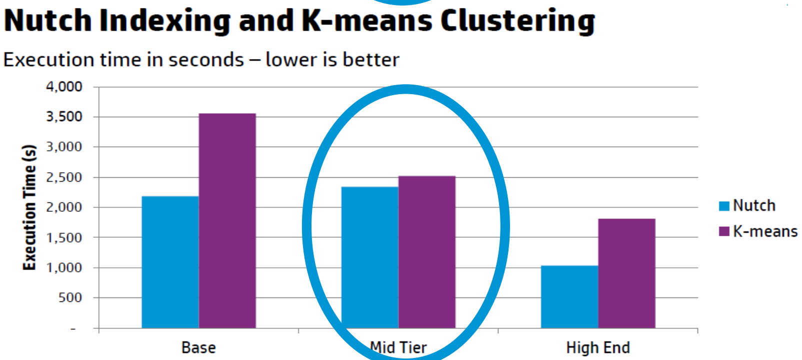
Data Analytics

- Query on data warehouse type data
- Complex queries with many joins and grouping/sorting operations



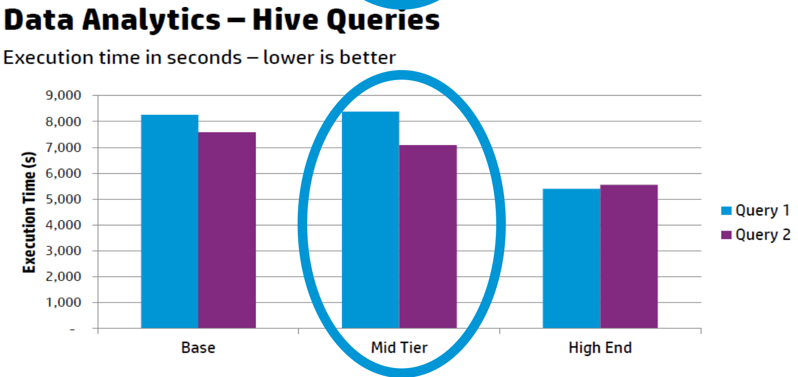
TeraSort

2TB TeraSort execution time results – lower is better



Nutch Indexing and K-means Clustering

Execution time in seconds – lower is better

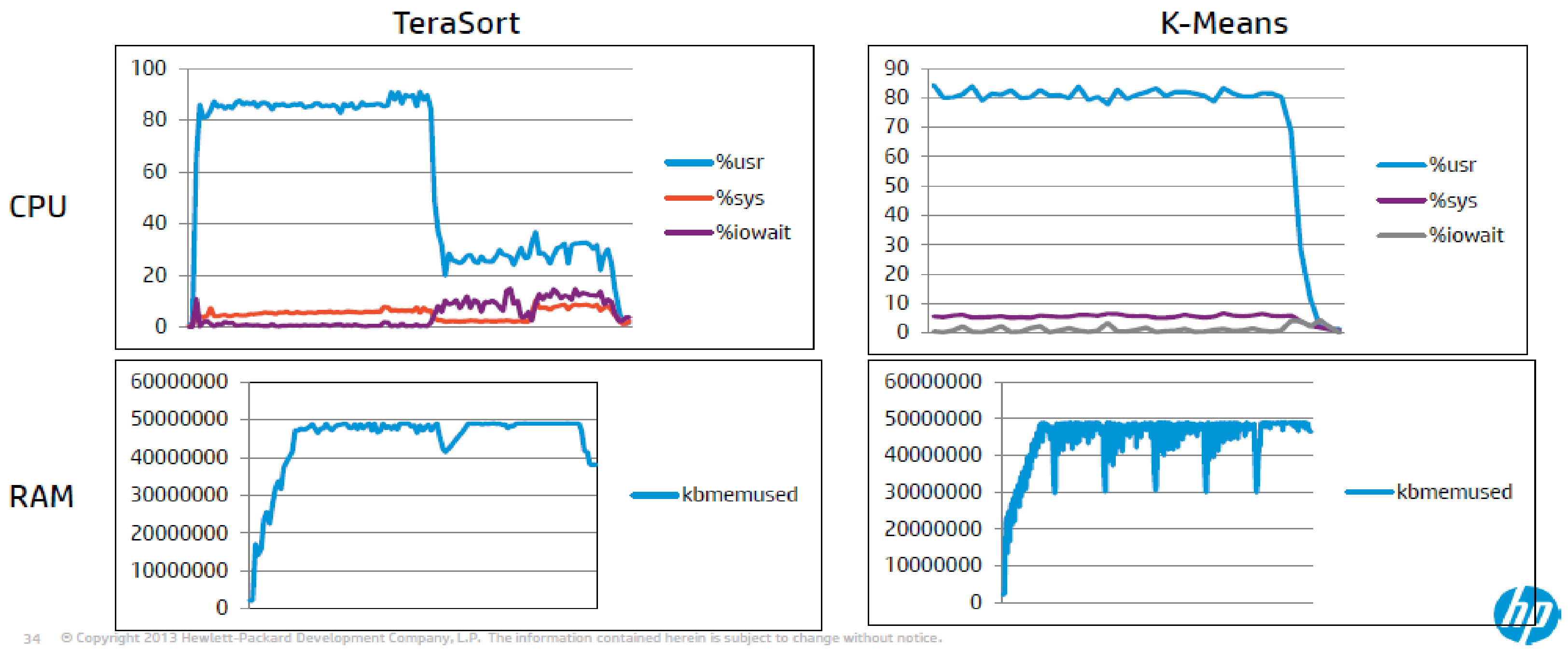


Data Analytics – Hive Queries

Execution time in seconds – lower is better

Note: Tests in 2013 using CDH 3.x

Ex: Evaluate limits



- Typically CPU, Memory, and or Disk I/O limited.
- Only networked limited about 10-15% of the time, if at all

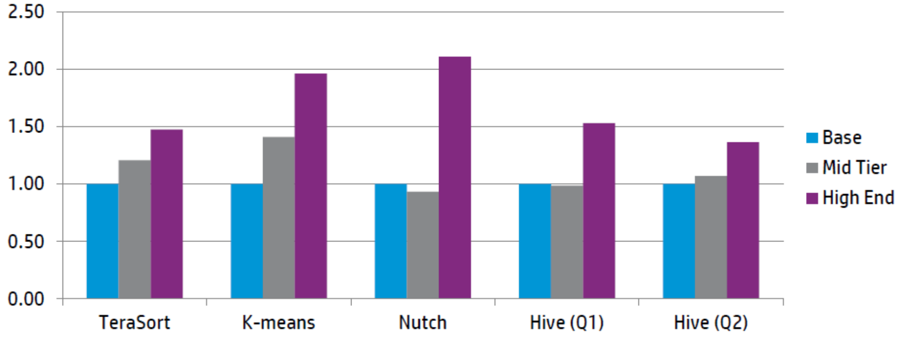
Ex: Evaluate tradeoffs

Performance vs. cost

- Sorting and Cluster workloads improved by 25% over base
- Node costs increase by 50% for each step
- Tradeoff improved disk reads at higher cost
- Idle power consumption improves energy use
- Tradeoff faster batch process at higher intermittent energy use

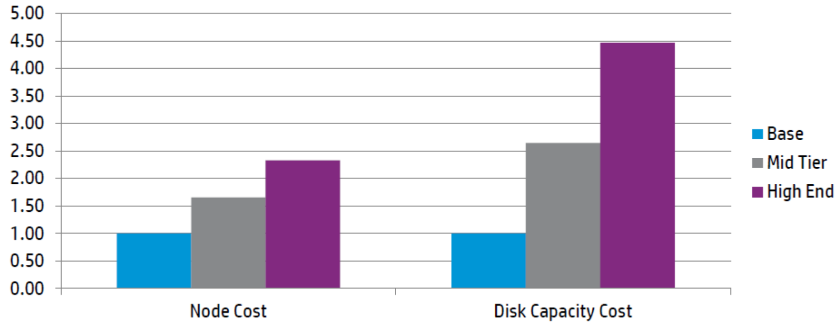
Relative Performance

Normalized results – Higher is better



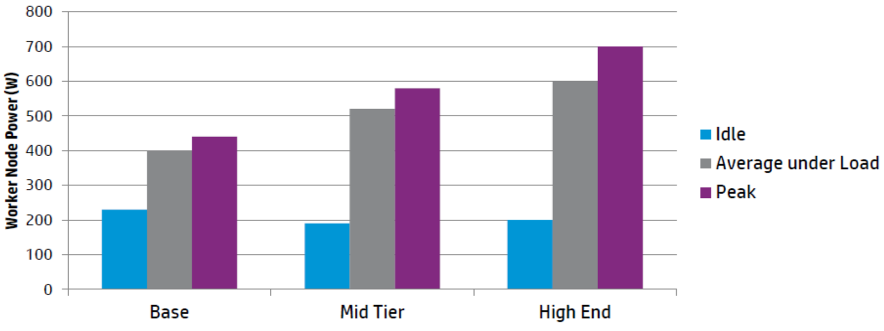
Relative Cost Comparisons

Relative Data Node Cost and Disk Capacity Cost – Lower is better



System Power Consumption

Worker Node Power Consumption (Watt) – Lower is better



Next Steps for Research

FP-I-C-PR-13 (Mid Range Server)

BO-MB (High)

SP-PM (low)

DS-CM (Med)

DS-AM (Med)

DC-VA (High)

DC-SR (Low)

DP-WC (High)

DA-AP-ML-CL (High)

DA-AP-ML-DF (Med)

DA-AP-ML-SA (Low)

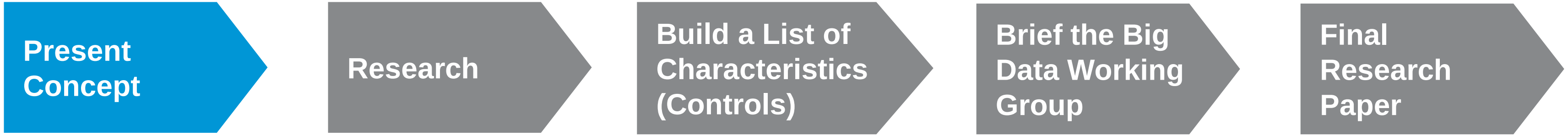
Additional Cataloguing Considerations

Between and Inside Components in the Taxonomy

- **Definitions and Taxonomy group named functional components**
- **We have not yet addressed the different ways the components work**
  - Or the different ways end-to-end systems work
- **Use cases give data-process lifecycles**
  - See Bob Marcus' M0297 high-level scenarios for use case categorization
- **Need to figure out the dimensions that differentiate component instantiations**
  - e.g. Inter-node communication -> implying latency in consistency
  - e.g. data location for processing (in-memory, on disk,…)
  - e.g. fault tolerant scheme (replication, master-slave, …)
  - e.g. analytics time constraints (streaming, interactive, batch,…)

Goal of Research

Convert Big Data WG Architecture and Use-Cases to Characteristic (Control) codes



Present Concept

- Create Taxonomies, Use cases, and architecture features
- Group functional components

Research

- Address component characteristics and behaviors
- Characterize different system/implementation behaviors
- Identify critical differentiators
- Gather published test results

Build a List of Characteristics (Controls)

- Map component characteristics, behaviors, and differentiators
- Assign codes
- Create evaluation criteria (low, medium, high)

Brief the Big Data Working Group

- Working Group briefings

Final Research Paper

- Publish or perish

Your feedback is important to us. Please take a few minutes to complete the session survey.

Thank you

Questions?

John.W.Rogers@hp.com
Nancy.W.Grady@saic.com